IEA Weyburn CO_2 Monitoring and Storage Project

Long-term Assessment of Fate of CO_2: Treatment of Abandoned Wells

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Outline of Talk

- Introduction to Weyburn EOR
- Assessment framework (methodology)
- Abandoned wells - issues and treatment
- Integration of results (planned!)

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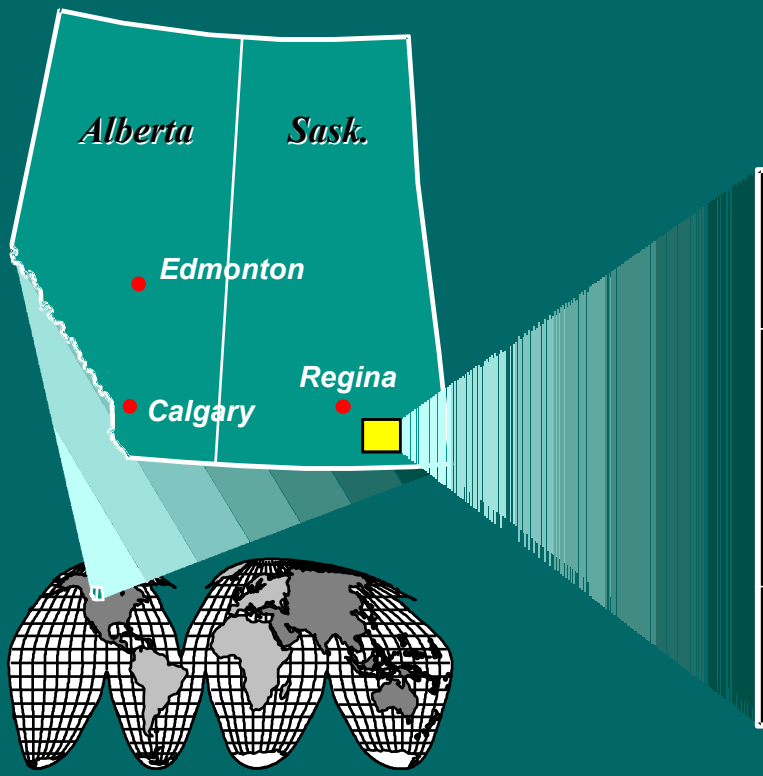
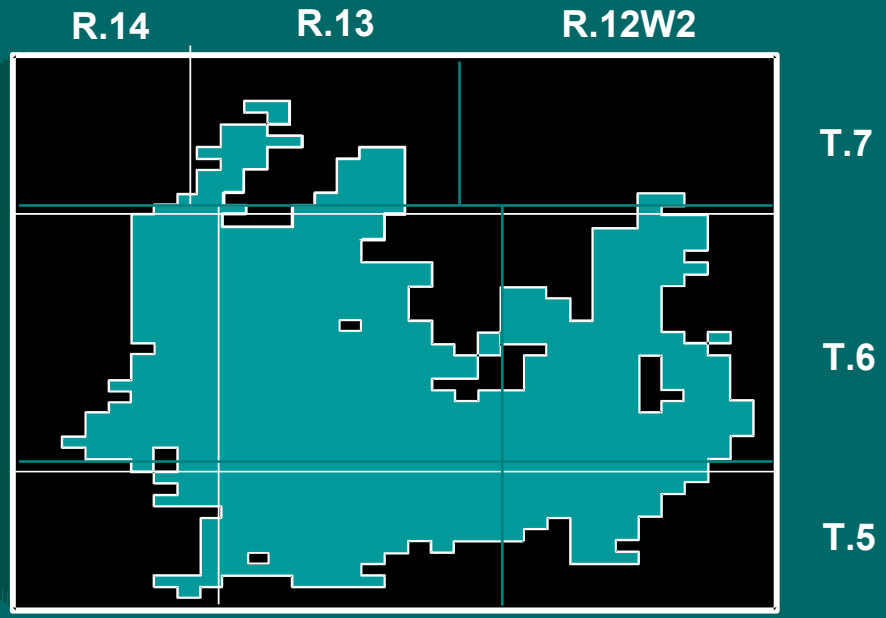
Weyburn Unit

(Slide courtesy of EnCana)



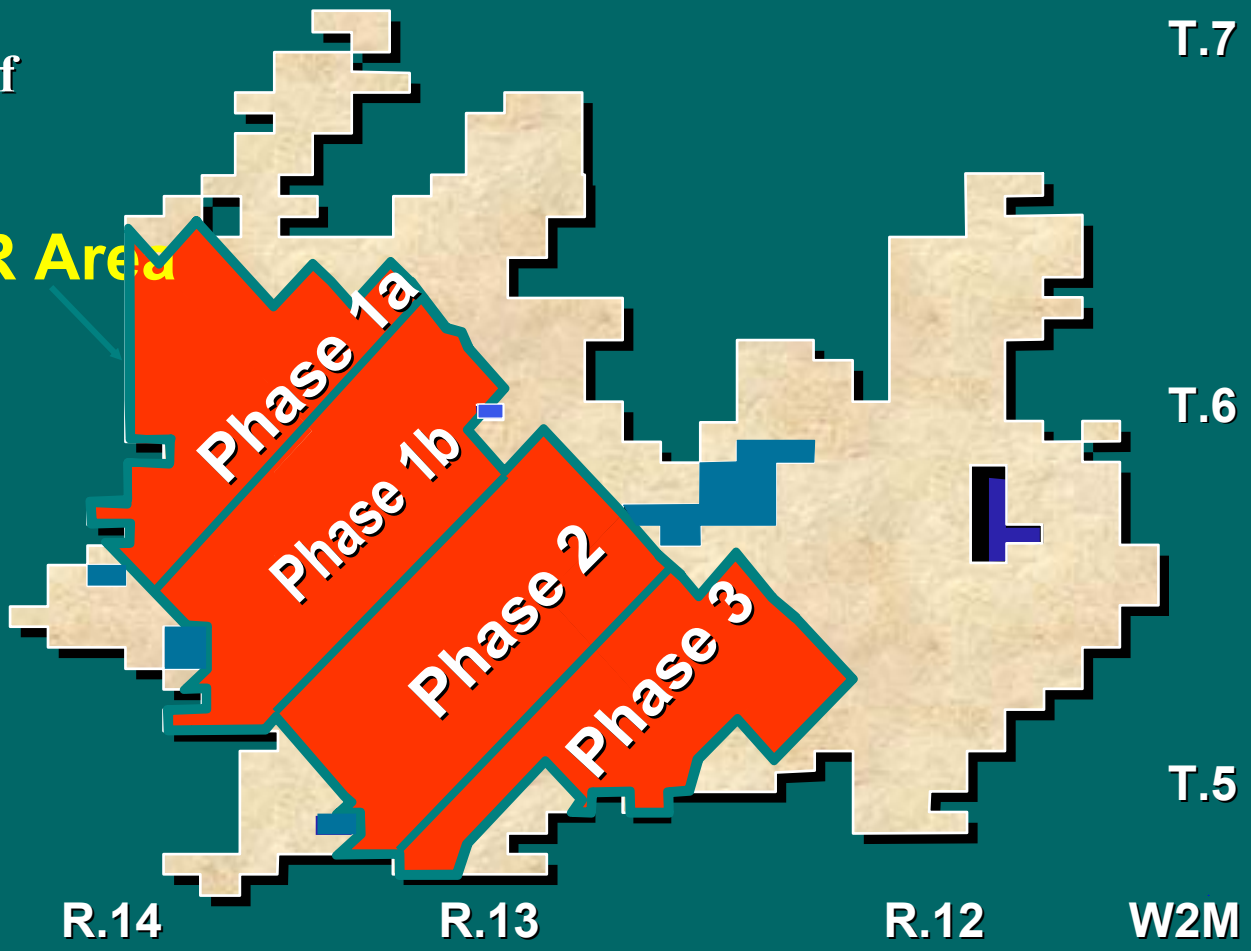


Field Size: 70 sq. miles

CO_2 injection started Sept. '00
CO_2 injected: 49 bcf (Dec. '02)

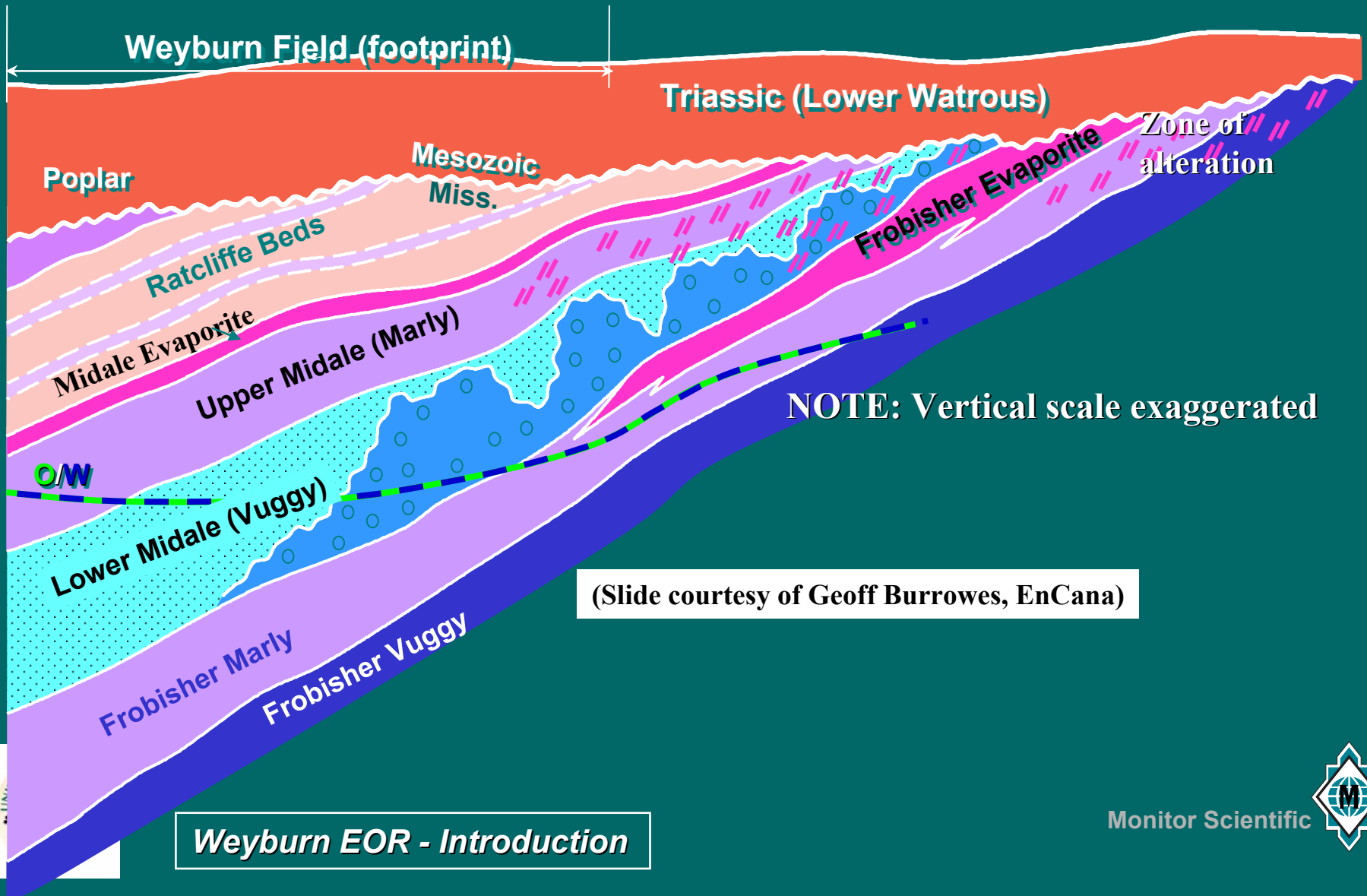
Rollout of the CO_2 Flood

(Slide courtesy of EnCana)



Weyburn Midale Field

Reservoir and Trapping Components



(Slide courtesy of Geoff Burrowes, EnCana)

Long-Term Assessment: Context

- **PERFORMANCE MEASURES**
  - ***Environmental-global*: whether any leakage of CO_2 compromises GHG reduction objectives**
  - ***Environmental-local*: whether any leakage of CO_2 represents an environmental risk to the local population (CO_2 concentration in air, water quality, toxic metal release)**
- **TIMESCALE**
  - **Governs what processes should be considered**
  - **Hundreds to thousands of years (modeling up to 5,000 years)**

Assessment framework

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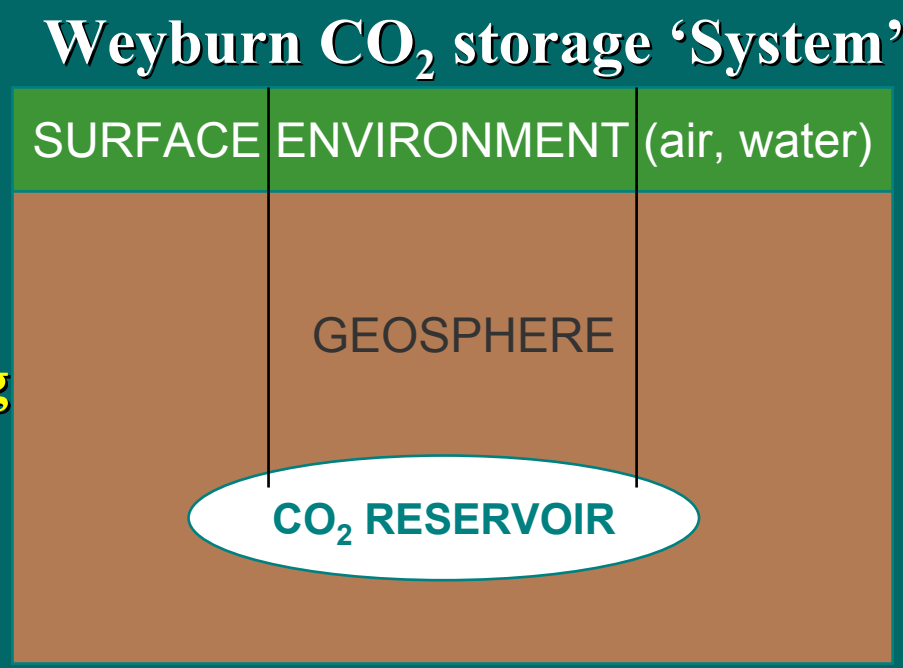
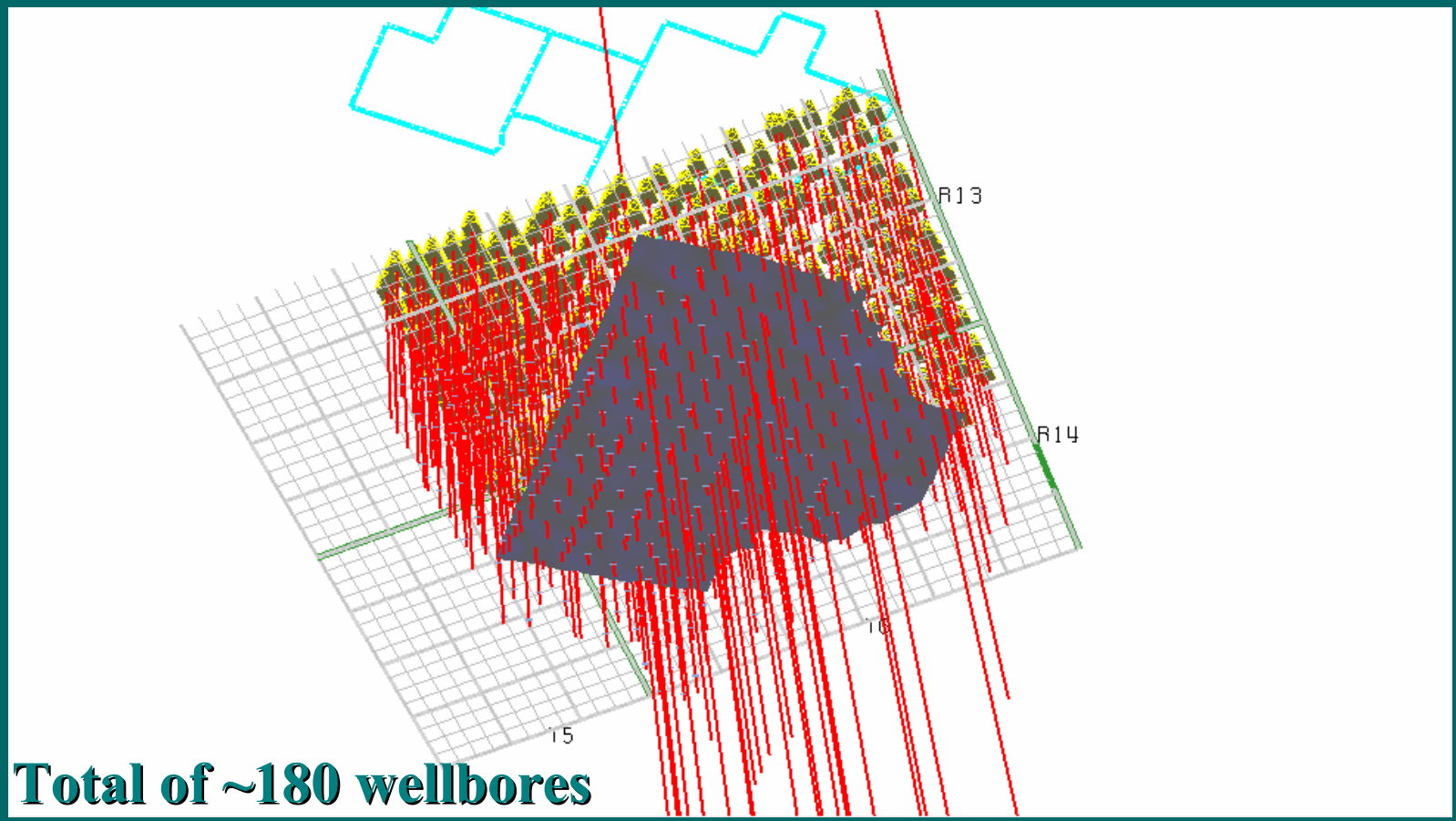
Long-Term Assessment Framework

- *Systems Analysis*
- Define Weyburn CO_2 'System'
  - storage field + surrounding geosphere + surface/near-surface environment, including atmosphere
- Identify possible ways in which the System can evolve
  - Base Scenario
  - Alternative Scenarios



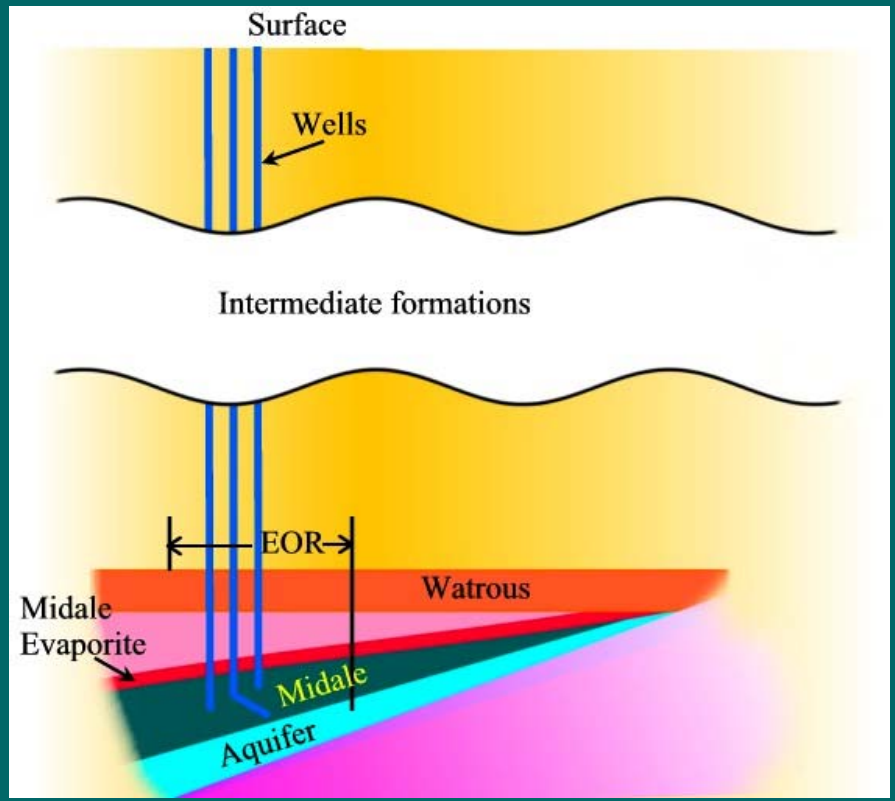
Vertical Extent of Weyburn System

Map of Wellbores (Phase 1A)



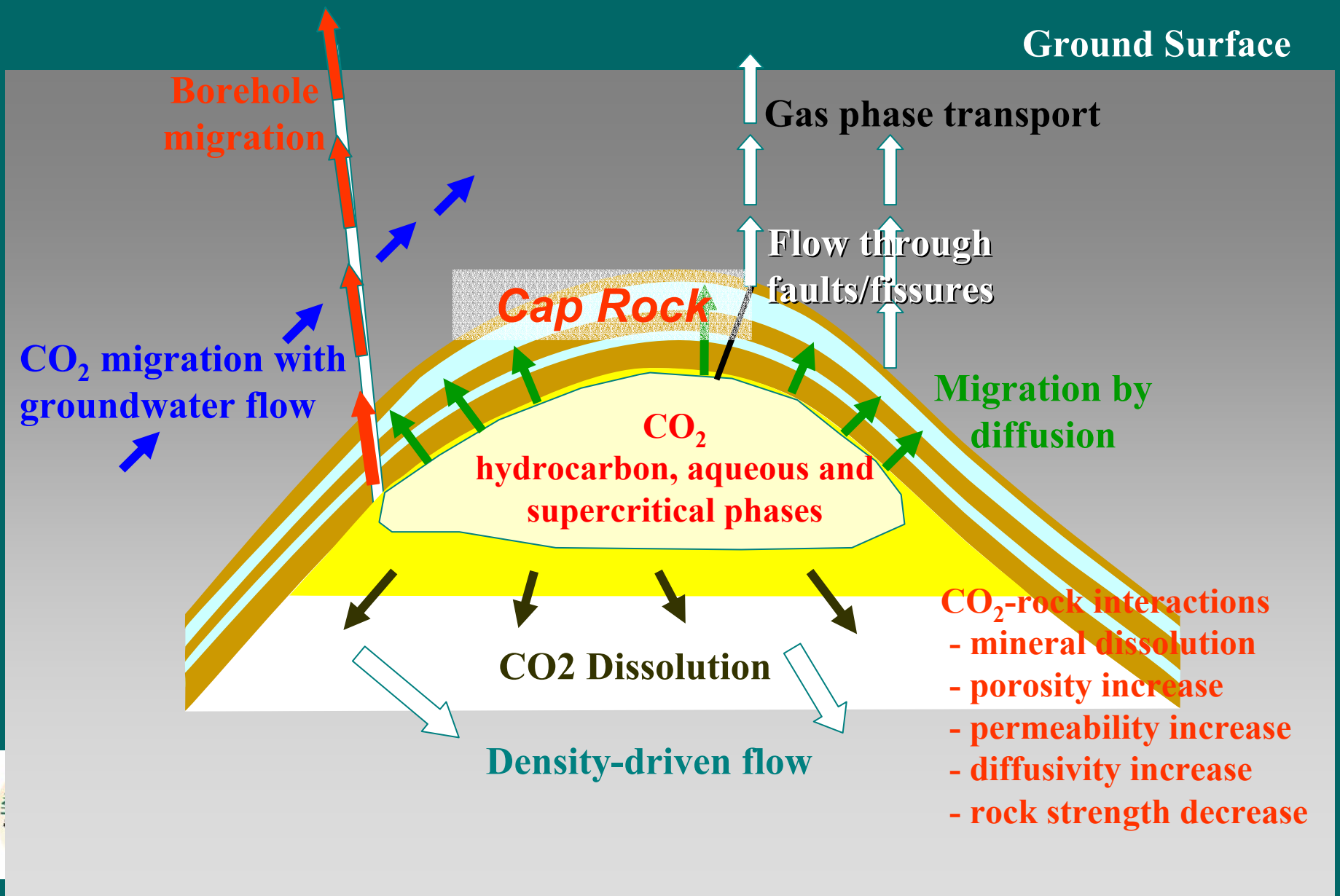
Total of ~180 wellbores

Weyburn - Base Scenario



- Defined as the "expected evolution of the Weyburn CO_2 storage system"
  - CO_2 migration pathways will be a combination of *natural* and *man-made* pathways
  - Wellbore casing seals will be assumed not to leak at time zero
  - CO_2 - rock - water interactions (long-term geochemical modeling)

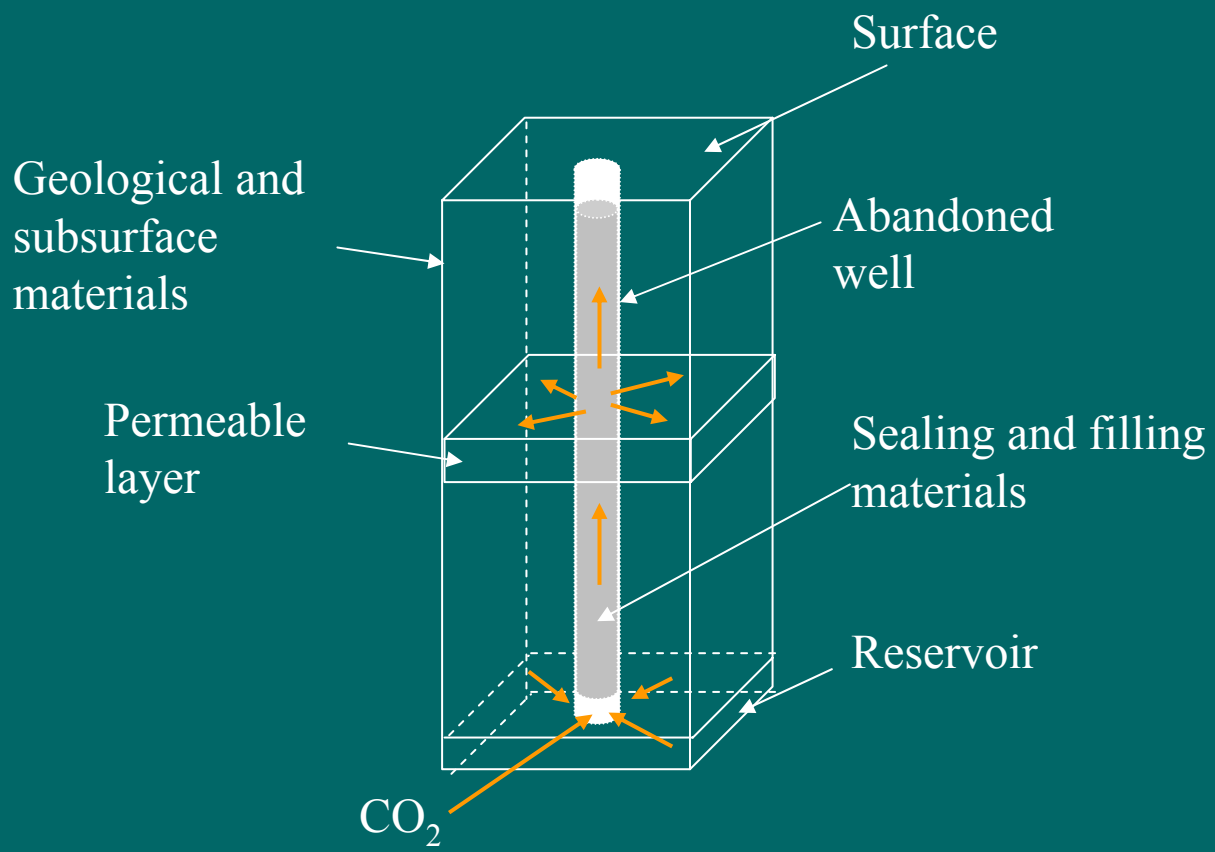
Possible Leakage Paths for CO_2



Probabilistic Treatment of CO_2 Leakage via Abandoned Wells

- *Not all wells are, or will be, equal*
- Need to address heterogeneities in
  - Transport parameters
    - Reservoir rock
    - Wellbore and annular seals (evolution with time)
  - Fluid distribution in reservoir
  - Hydraulic connection between wellbore and surrounding formations (metal casing corrosion)

"Unit Cell" Representation of Abandoned Well



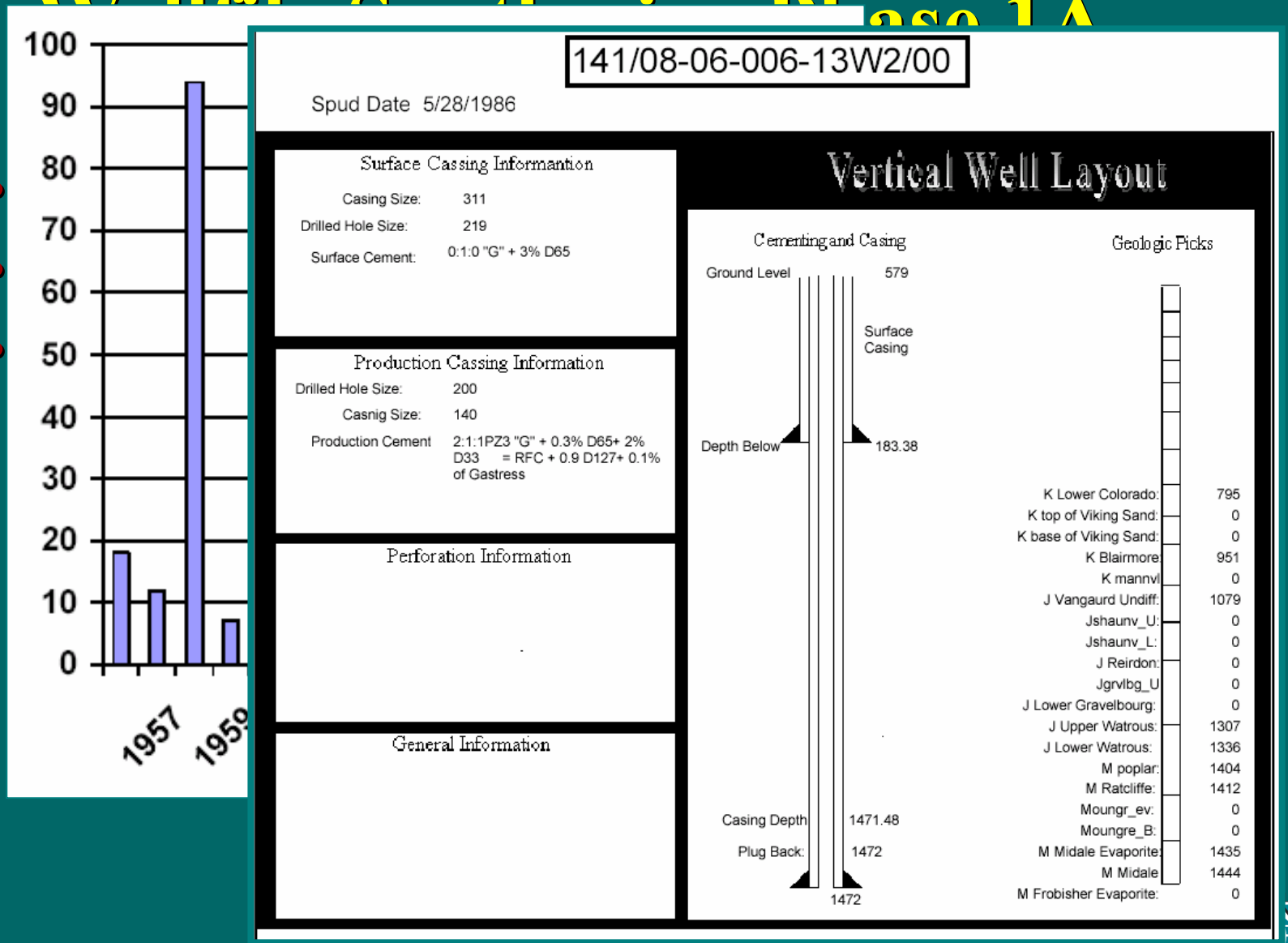
Approach to Abandoned Wells

- Detailed study being carried out by University of Alberta (UofA), using 'real' data to:
  - examine conditions of wellbores, both pre-CO_2 injection and post-CO_2 injection (EOR) phases
  - predict impact of geomechanical and geochemical effects on transport properties and, hence, leakage of CO_2
- UofA results will then be used by Monitor Scientific (MSCI) as input to long-term assessment

Wellbore Leakage: Information /Data Input

- Well file information (well file database)
- Digital records (logs, production, injection)
- Simulation results (reservoir)
- Geologic 3-D Model
- Analytical Models (*e.g.* geochemical, geomechanical)
- Numerical Models (*e.g.* borehole stability)
- Laboratory Experiments

Wellfile Synthesis Phase 1A



Abandoned wells - issues

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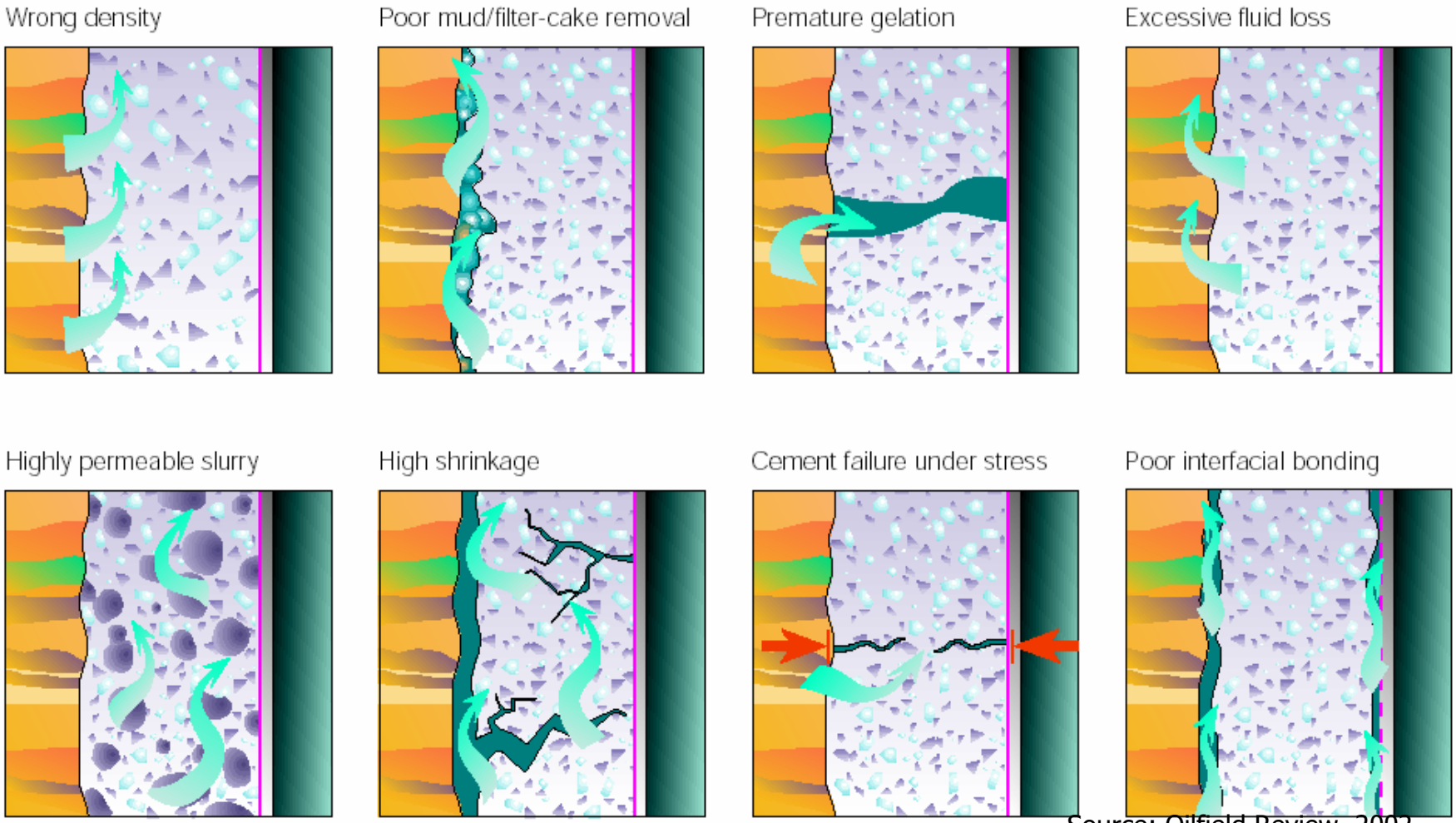
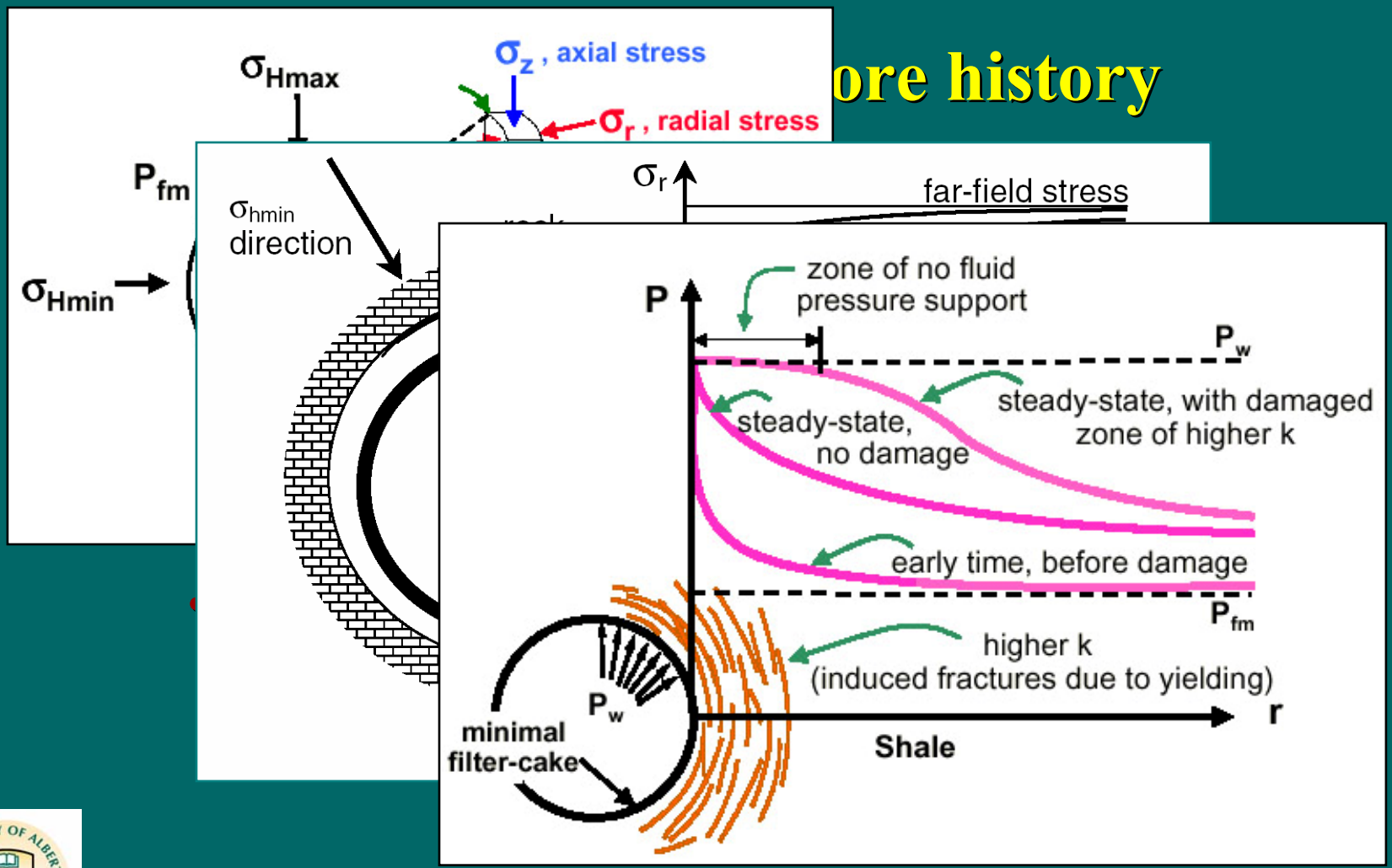
Wellbore Annulus Seal Heterogeneity



Source: Oilfield Review, 2002

Assessment of Wellbore Leakage

ore history



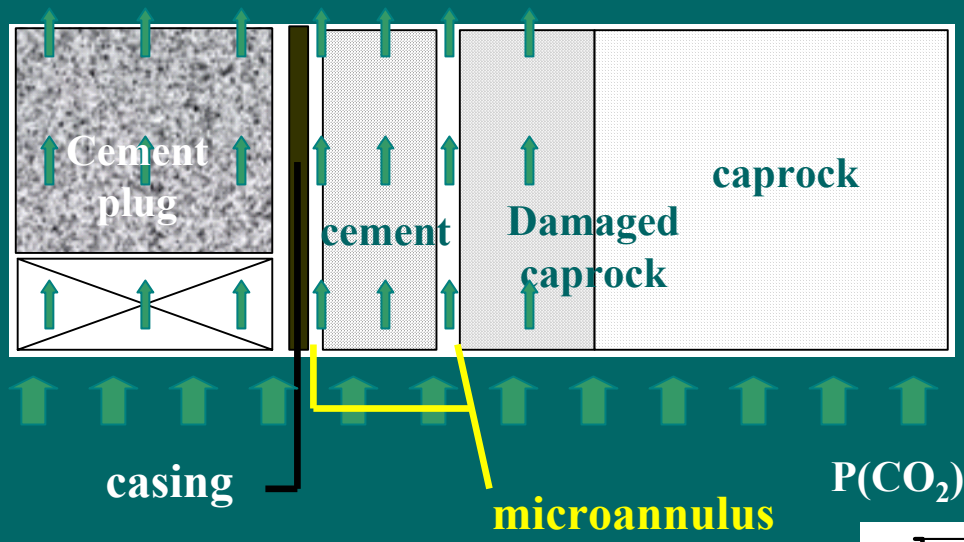
Abandoned Wells: Long-Term Evolution Chemical/Geochemical Changes

- *Degradation of cement* (casing seals, annular seals)
  - Carbonation, attack by sulphate, chloride
  - Changes in porosity, permeability will affect transport properties of seals
- *Corrosion of metal* casing
  - Ultimately, localized casing failure will allow hydraulic connection with surrounding formations

Interaction of Supercritical CO_2 with Cement

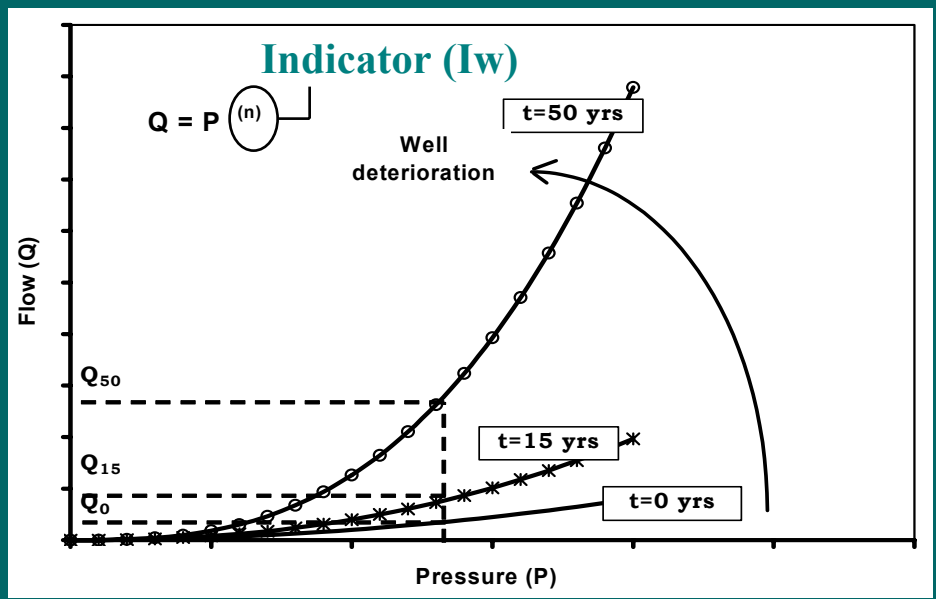
- Overall effect comprises accelerated carbonation, depth penetration, and even greater porosity reduction than under 'natural' conditions
- Mechanical effects?
  - possible brittle nature of carbonated cement phases?
  - potential for cracking?

Process Modelling: CO_2 Flow in Wells



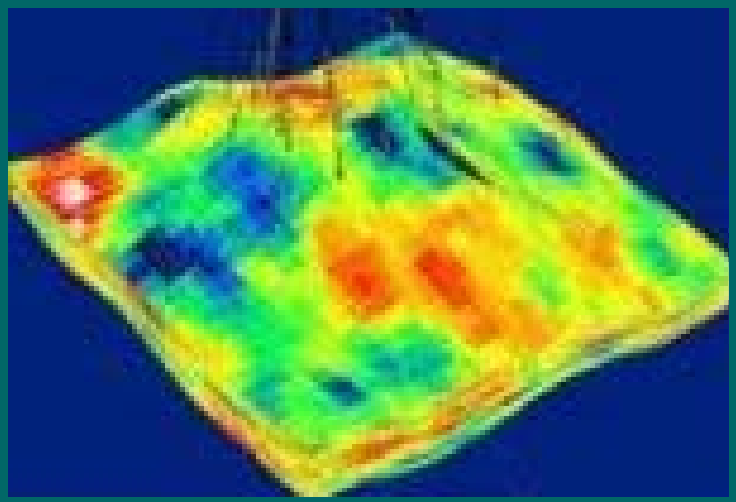
Conceptual model

Results format
[Flux =f(P)]



Integration of results

Assessment of Abandoned Wells: Output – Combined Wells



Hypothetical output

- "Real" field data (well files, production data, etc.), combined with analytical or numerical simulations, used to quantify the likelihood of "leakage" from individual wells.
- Focus attention on higher risk areas for post-CO_2 injection phase assessment

Phase 1A Results: Input to Long-Term Assessment

- Extrapolation of detailed (Phase 1A) results to entire assessment area
  - Assume similar statistics for Phase 1A predictions apply to rest of field (assumption can be tested)
- Use predicted well flux rates as distributed *sinks* with respect to CO_2 migration modeling in the geosphere

Acknowledgements

- *The long-term assessment relies on information/data being provided by almost all Research Providers involved in the IEA CO_2 Monitoring and Storage Project*

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